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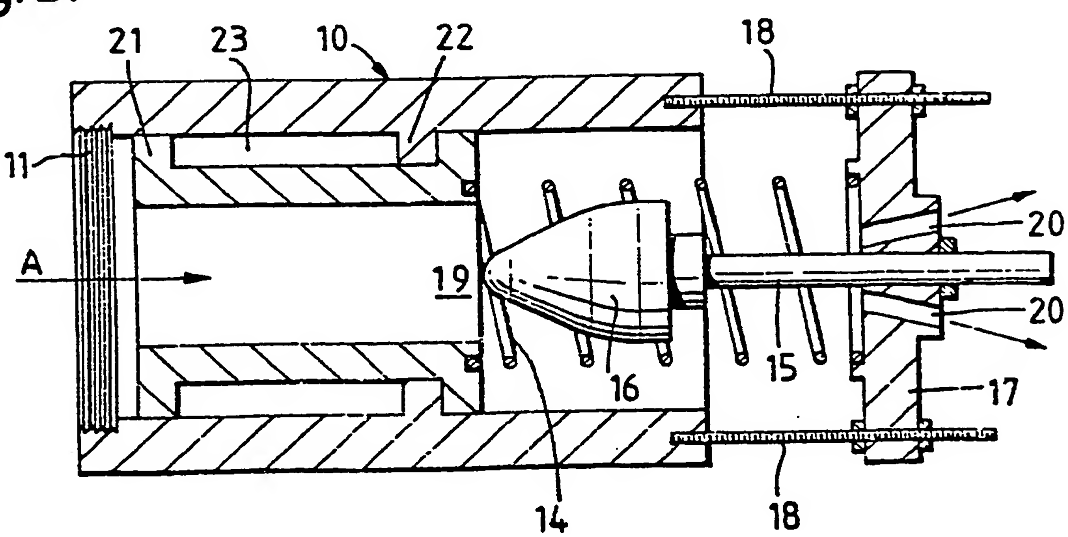
F2V
Selected US specifications from IPC sub-classes
G05D F16K

(54) **Flow control device**

(57) A flow control device for controlling flow through, for example, sensors towed through water consists of a hollow body (10) through which fluid flows. Inside the body (10) is a hollow piston (21) which is moved by pressure of fluid flow against the action of a spring (14). An orifice control needle (15) with a tapered head (16) is attached to the body (10) and movement of the piston (21) causes changes in the size of the orifice (19) created between the piston (21) and the tapered head (16). Under minimum flow conditions the orifice (19) is at its maximum size. As the flow increases the piston (12) is moved against the spring (14), decreasing the size of the orifice (19) and thus restricting the flow through the flow control valve. In this way the device can enable a substantially constant output flow rate to be achieved for a range of input flow rates.

Fig. 3.



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The drawing(s) originally filed was (wer) informal and the print here reproduced is taken from a later filed formal copy.

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Fig.1. PRIOR ART

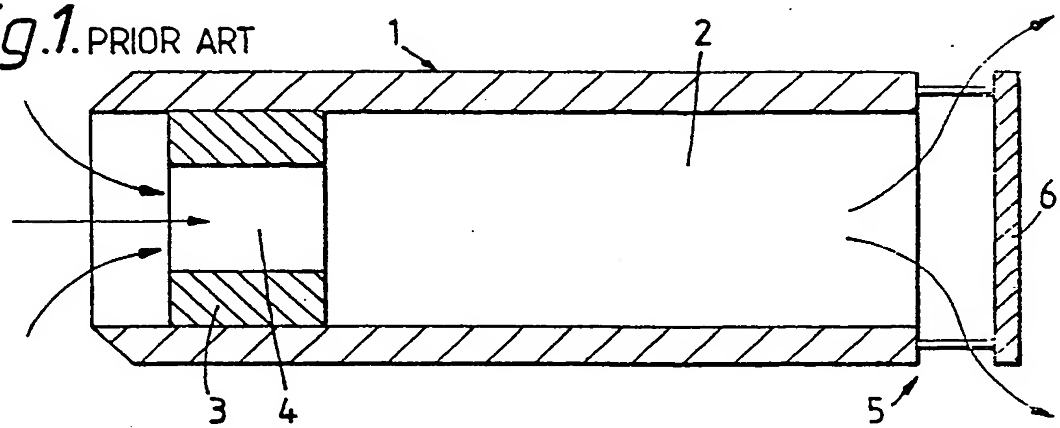


Fig.2.

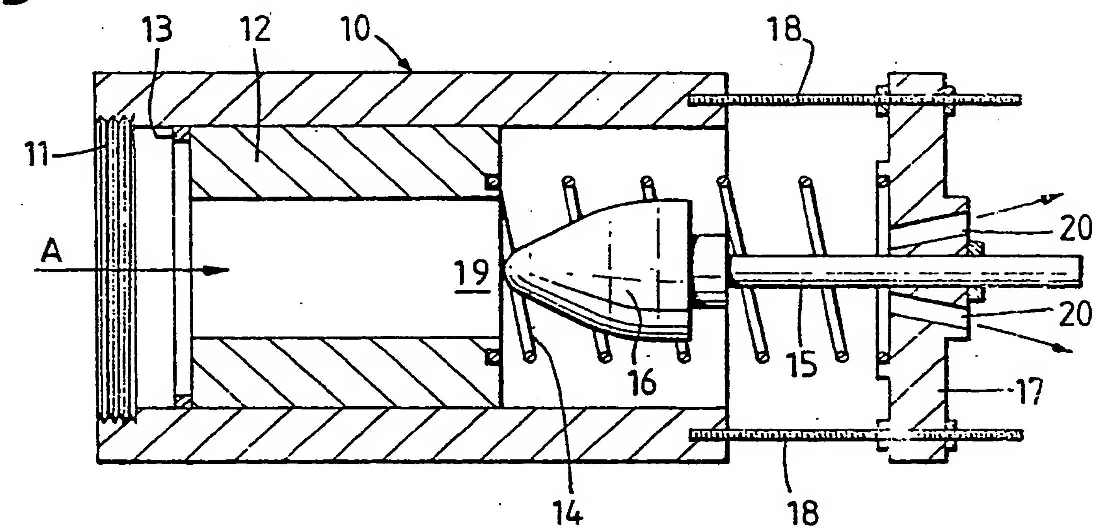


Fig.3.

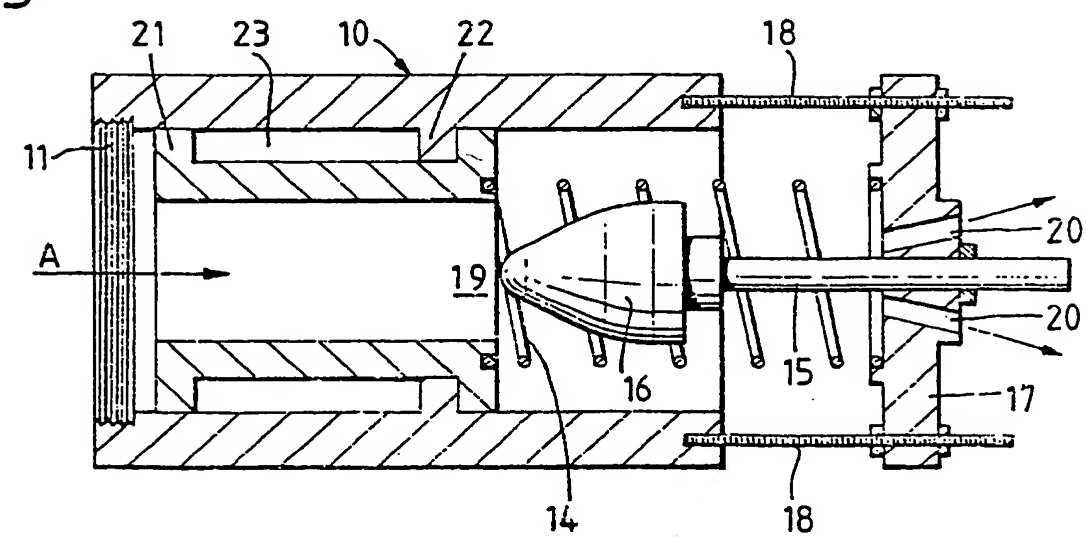
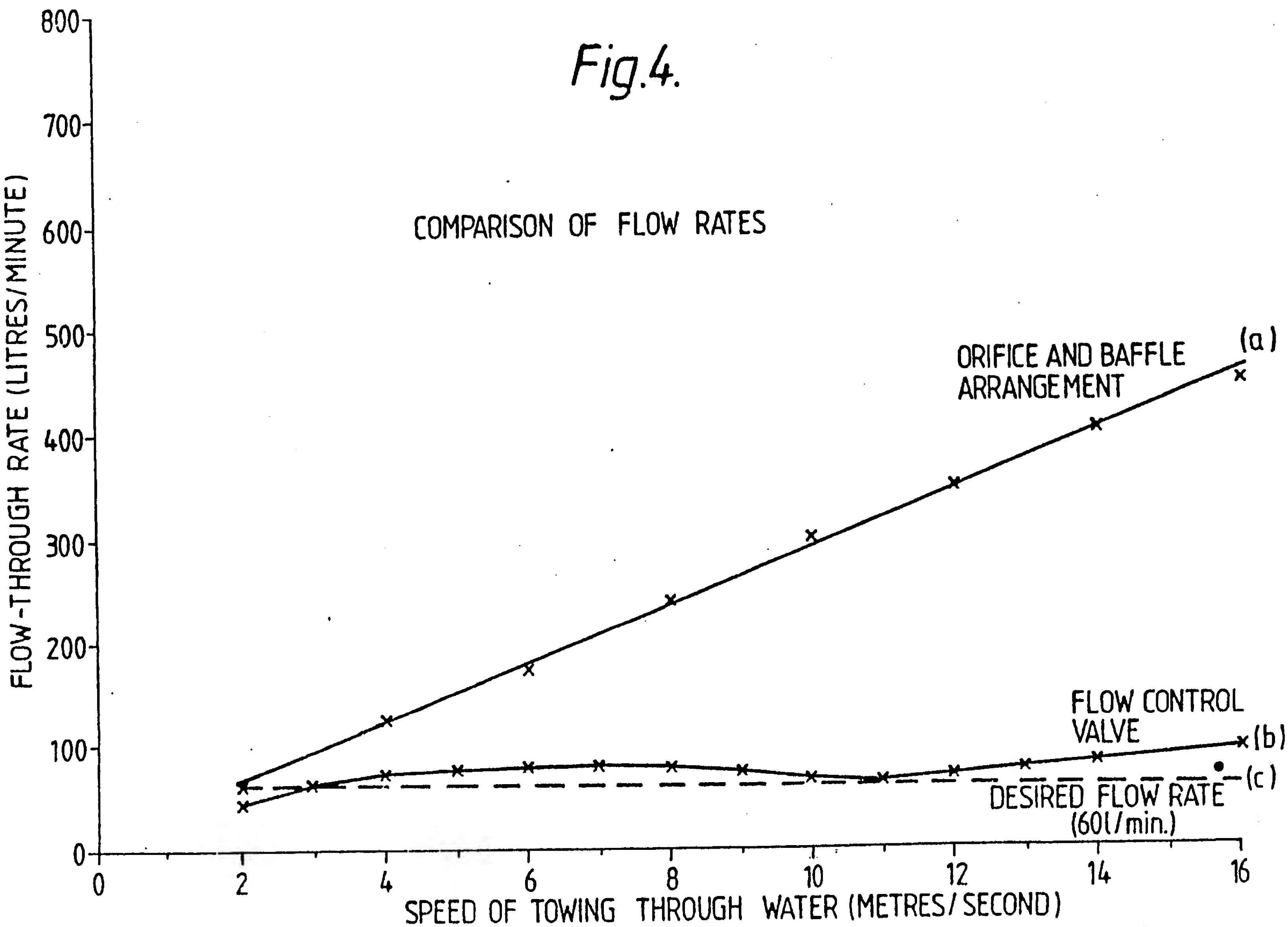


Fig.4.



COMPARISON OF FLOW RATES
FLOW-THROUGH RATE (LITRES/MINUTE)
800
700
600
500
400
300
200
100
0
ORIFICE AND BAFFLE ARRANGEMENT
(a)
FLOW CONTROL VALVE
(b)
(c)
DESIRED FLOW RATE (60l/min.)
0
2
4
6
8
10
12
14
16
SPEED OF TOWING THROUGH WATER (METRES/SECOND)

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FLOW CONTROL DEVICE

The present invention relates to devices for controlling the flow-through rate of a fluid, principally but not exclusively for controlling the rate of flow of a fluid through a body which is moving relative to the fluid.

There is a requirement for a device which can control the rate of flow of a fluid through a body moving relative to the fluid such that the rate of flow through the body is substantially independent of the relative speed of the fluid and the body.

There is a particular requirement for a device which can control the flow of water through an electrochemical cell or other sensor which is either towed through the water or placed in running water. As the effect of the relative speed of a body and flow control device to a fluid is independent of whether it is created by towing of the body through the fluid or by the fluid moving past a stationary body, further references in this specification to the towing of bodies through a fluid should be taken to cover any situation where a relative speed between the body and the fluid exists. Additionally, references to water should be taken to refer to any flowing fluid.

For these sensors it is particularly desirable that the rate of flow through the sensor is independent of the speed of the sensor through the water and that it can be controlled at a desired flow rate between certain minimum and maximum towing speeds.

There are many types of device known for controlling flow in closed pipelines but these are not suitable for situations where the pressures generated can differ greatly. Known flow control devices are unable to cope with the wide range of input flows that have to be controlled, for example, in the open water towing situation where input flows of between 2m/sec and 16m/sec (4 knots to 32 knots) may commonly be experienced and where the device may have to operate at depths down to 240m or more. Another problem with known closed pipe valves is that in many of them the control principle relies on the use of side exit ports which can affect the pressure differential across the device such that they cannot be adapted to operate effectively in certain types of usage outside closed pipe situations.

As known flow control devices have been found to be unsuitable for controlling flow rates in open water situations an alternative solution to the problem had to be found. A suggested solution has been the use of fixed orifices at the front of the towed body and fixed gap baffles at its rear.

However, it is impossible for such a system to provide a constant flow-through rate. The flow-through rate will always increase with the speed through the water.

The only previously acceptable way of providing a constant flow through rate for a sensor or other such device has been to pump water through at a constant rate - this provides a constant flow-through rate but is costly and complex.

The object of the invention is to provide an improved flow control device, to control the rate of flow of a fluid through a body moving relative to the fluid, which is capable of controlling the flow-through rate so that it is substantially independent of the relative speed of the body and the fluid.

It is desirable that the flow control device should have a minimum of moving parts for simplicity of manufacture and that it should have no rubber seals as these change their characteristics at depth (ie they can become compressed so that either they do not seal or else they become harder and prevent moving parts moving freely). It is also considered desirable to have a device with no electrical or hydraulic parts.

The invention provides a flow control device comprising:

a) a hollow body through which fluid can flow;

b) a moveable, hollow piston held within the hollow body, one end of the piston defining a fluid orifice through which fluid can flow and the piston being moveable against the action of resilient means by the pressure of the fluid flow; and

c) an orifice control means further defining the fluid orifice such that the size of the orifice through which fluid flows is controlled by the movement of the piston in relation to the orifice control means;

wherein the orifice control means comprises an orifice control needle with a tapered head, held in position on the device body, the taper of the head being orientated such that an increase in the speed of fluid flow into the device causes the piston to move to a position where the cross-section of the head is increased thus decreasing the orifice size and the taper of the head having a profile such that a desired output flow rate from the device can be achieved for a specified range of input flow rates.

Preferably the flow control device according to the invention further includes means by which oscillation of the piston means is damped or avoided. Such oscillation may be caused by the action of the resilient

means.

Preferably the orifice control needle and the resilient means are held in position by means of a support plate attached to the device body. Preferably the support plate is arranged so that it does not interfere with the flow through the device. Conveniently holes are provided in the support plate to allow flow-through of the fluid. Thus, fluid can flow directly through the device.

The resilient means is conveniently a compression spring. The spring rate is selected to give a desired movement back of the piston means under the pressure of the fluid flow. The compressive length of the spring determines the necessary length of the tapered head on the orifice control needle. The taper of the needle head in combination with the spring rate determines the change in orifice size with fluid flow rate.

The hollow piston may be moveable between predetermined limits. Preferably means are included to prevent the piston means moving further forward than the rest position under minimum flow conditions.

Preferably the orifice control needle is adjustable to the desired operating position. Conveniently the position of the tapered head of the orifice control needle and its size and taper are such that the flow is shut off above a certain input flow rate.

The device may be any shape but for convenience is cylindrical. In this form the piston is a hollow cylinder which fits closely into the device body.

Preferably the piston is a "cotton reel" shape (ie the outer diameter of the piston is larger at its end sections than at its centre section) and there is included a flow restriction means between the piston means and the device body. The flow restriction means is positioned between the two ends of the piston such that relative movement of the piston and the restriction means can occur along the centre section of the piston. The flow restriction means preferably comprises a ring of a size such that a gap is created between the ring and the piston past which fluid may flow. Alternatively holes may be provided in the ring to enable fluid flow. The ring acts as a damping means as water between the piston means and the device body wall must flow past it when the piston means is moved. The ring should be of a size to act as a damping means without preventing the piston means from moving. The ring may also act as a stop means to limit the movement of the piston.

The combination of a "cotton reel" shaped piston and a ring produces a self-damping piston.

The ring may be inserted into the device body or may be formed integrally with the body. The ring could alternatively be replaced by a rubber seal type ring in situations where there will be no adverse effects on the seal due to depth etc.

The bore size of the piston is selected to give a desired flow rate at the minimum design speed.

The device should preferably be positioned behind the sensor or other towed body to avoid turbulent flow effects.

The invention will now be described, by way of example only, with reference to the drawings, of which:

Figure 1 shows in cross section a schematic representation of a prior art system of controlling the flow rate through a towed body using a fixed orifice and baffle plates;

Figure 2 shows in cross section a schematic representation of one embodiment of the invention; and

Figure 3 shows in cross section a schematic representation of a preferred embodiment of the invention.

Figure 4 is a graphical comparison of the performance of the prior art system of Figure 1 and the preferred embodiment of Figure 3.

All the Figures will be described in relation to controlling the flow through an example device of an electrochemical cell of bore 5cm and length about 120cm when it is towed through water. For this example cell it is desirable that the flow through the cell be controlled at a substantially constant rate within the range 40 to 100 litres per minute with a desired flow rate of 60 l/min at all speeds of the cell through the water from 2 m/sec to 16 m/sec.

Figure 1 shows a prior art system of controlling the rate of flow of water through a device. A device such as an electrochemical cell has a body 1, having a bore 2 of diameter 5cm, through which water flows. It has been shown experimentally that a 2.5cm diameter bore gives an adequate flow through the example cell at 2m/sec. An insert 3 is fixed in the bore 2 of the cell to provide an input flow orifice 4 with a diameter of 2.5cm. At the rear 5 of the cell body 1 a baffle plate 6 is attached with a gap of about 0.3cm from the body 1. Water flows in through the input orifice 4, through the cell body 1 and out around the baffle plate 6. Experimentally this was found to

be the best combination of front orifice and rear baffle and flows of 60 l/min at 2 m/sec rising to 450 l/min at 16 m/sec were achieved.

Using this means of flow control the flow through the cell rose above the desired level at speeds not much faster than the minimum design speed and thus this means of control is inadequate for the flow control requirements of the electrochemical cell.

A device that is capable of controlling the flow to a constant flow-through rate is required. Such a device is shown in Figure 2 which illustrates one embodiment of the invention.

The device of Figure 2, called a flow control valve, comprises a body 10 which attaches by fitment means 11 to the rear 5 of the body 1 of the electrochemical cell shown in Figure 1 (without insert 3 and baffle plate 6).

The body 10 is a hollow cylinder through which water flows in the direction of arrow A. Inside the body 10 is a hollow cylindrical piston 12 which is held in position between a stop ring 13 and a spring 14. The flow of water through the body 10 causes the piston 12 to be moved under the pressure of the fluid flow. An orifice control needle 15 with a tapered head 16 is attached to the body 10 by means of a support plate 17 and a number of attachment bolts 18. As the piston 12 moves back under the pressure of the water flow against the spring 14 such that the spring 14 is compressed, the size of the orifice 19 created between the piston 12 and the tapered head 16 changes. Thus under the minimum flow conditions the orifice 19 is at its maximum size and as the flow rate increases, moving the piston 12 against the spring 14, the size of the orifice 19 decreases, thus restricting the flow through the flow control valve.

Flow-through holes 20 are provided in the support plate 17 and it has been found that substantially all the water flow passes out through these holes 20.

It has been found that under certain conditions the piston 12 can begin to oscillate under the combined actions of the water flow pressure and the spring 14. The preferred embodiment of the invention includes a means by which such oscillations can be damped out.

As shown in Figure 3, the preferred embodiment of the invention differs from that shown in Figure 2 only in the piston 21 and a flow restriction ring 22. The piston 21 is "cotton reel" shaped in that the external diameter of its end sections is greater than the external diameter of its centre section. The piston 21 fits over the ring 22. The ring 22 is

here formed integrally with the body 10. The ring 22 acts as a damping means in that the water in the cylindrical space 23, between the piston 21 and the body 10, must flow past the ring 22 to fill the gap created between the ring 22 and the downstream end of the piston 21. This flow is restricted and it causes lag in the movement of the piston 21. Thus the combination of the "cotton reel" shaped piston 21 and the ring 22 creates a self-damping piston which prevents oscillations being set up due to the action of the spring 14. The ring 22 also acts as a stop ring.

Figure 4 shows a graphical comparison between the flow rates through the example cell as achieved using flow control means of the orifice and baffle arrangement of Figure 1, as shown at (a) and the flow control valve of Figure 3, as shown at (b). The desired flow rate of 60 litres/min is shown at (c). As can be seen, the flow control valve of Figure 3 has produced a nearly constant flow rate, over the range of towing speeds, close to the desired flow rate. Further refinement of the taper of the control needle head 16 would be possible to make the flow constant at a desired rate if such accuracy was required.

The device can be made from readily available materials for ease of construction and cost. The choice of materials is only limited by their ability to withstand the effects of corrosion, particularly if used in seawater, and the pressures encountered at depth. However, all metal parts in the device should preferably be of the same metal to avoid electrolysis effects. Stainless steel is one possibility as this metal can readily be used to make springs with suitable characteristics for the device.

The flow control device of the invention has many advantages over prior art systems. Known devices do not appear to be capable of coping with the wide range of input flow rates which this device can control. Further, the majority of devices available are not designed to control flow rates outside of closed pipe situations, such as when towed in open water.

The device of the invention is simple and self-contained. It has no hydraulic or electrical parts, making manufacture and maintenance simple and cheap.

The flow through the flow control device, and hence any device to which is attached (which may be a sensor such as an electrochemical cell for monitoring pollution in rivers or harbours) can be made independent of the input speed of the water.

A further advantage following from the construction of the device is

that it is self-cleaning in that if organic matter is carried into the device by the flow of water, it is disintegrated and flushed through by the continuing flow.

Though particularly useful in the towed or flowing water situations, the invention can also be adapted for use in pipe systems.

CLAIMS

1. A flow control device comprising:

   a) a hollow body through which fluid can flow;

   b) a moveable, hollow piston held within the hollow body, one end of the piston defining a fluid orifice through which fluid can flow and the piston being moveable against the action of resilient means by the pressure of the fluid flow; and

   c) an orifice control means further defining the fluid orifice such that the size of the orifice through which fluid flows is controlled by the movement of the piston in relation to the orifice control means;

wherein the orifice control means comprises an orifice control needle with a tapered head, held in position on the device body, the taper of the head being orientated such that an increase in the speed of fluid flow into the device causes the piston to move to a position where the cross-section of the head is increased thus decreasing the orifice size and the taper of the head having a profile such that a desired output flow rate from the device can be achieved for a specified range of input flow rates.

2. A flow control device according to claim 1 wherein there is further included means by which oscillation of the piston means is damped or avoided.

3. A flow control device according to claim 1 or claim 2 wherein the orifice control needle and the resilient means are held in position by means of a support plate attached to the device body.

4. A flow control device according to claim 3 wherein the support plate is arranged so that it does not interfere with the flow through the device.

5. A flow control device according to claim 3 or 4 wherein holes are provided in the support plate to allow flow-through of the fluid.

6. A flow control device according to any one of the preceding claims wherein the resilient means comprises a compression spring and the spring rate of the spring is selected to allow a desired movement of the piston under the pressure of fluid flow.

7. A flow control device according to any one of the preceding claims wherein the piston is moveable between predetermined limits.

8. A flow control device according to any one of the preceding claims wherein means are included to prevent the piston means moving further forward than the rest position under minimum flow conditions.

9. A flow control device according to any one of the preceding claims wherein the orifice control needle is adjustable to the desired operating position.

10. A flow control device according to any one of the preceding claims wherein the position of the tapered head of the orifice control needle and its size and taper are such that the flow is shut off above a certain input flow rate.

11. A flow control device according to any one of the preceding claims wherein the piston is a hollow cylinder which fits closely into the device body.

12. A flow control device according to claim 11 wherein the piston is a "cotton reel" shape (ie the outer diameter of the piston is larger at its end sections than at its centre section)

13. A flow control device according to claim 12 wherein there is included a flow restriction means between the piston means and the device body, the flow restriction means being positioned between the two ends of the piston such that relative movement of the piston and the restriction means can occur along the centre section of the piston.

14. A flow control device according to claim 13 wherein the flow restriction means comprises a ring of a size such that a gap is created between the ring and the piston past which fluid may flow.

15. A flow control device according to claim 13 wherein the flow restriction means comprises a ring having with holes to enable fluid flow.

16. A flow control device according to claim 14 or claim 15 wherein the ring is of a size to act as a damping means without preventing the piston means from moving.

17. A flow control device according to any one of claims 14 to 16 wherein the ring also acts as stop means to limit the movement of the piston.

18. A flow control device according to any one of the preceding claims wherein the bore size of the piston is selected to give a desired flow rate at the minimum design speed.

19. A flow control device as hereinbefore described with reference to Figure 3 of the drawings.